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Computing degree apprenticeships: An opportunity to address gender imbalance in the IT sector?

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Abstract—This paper explores the potential for new work-based apprenticeship degrees to encourage more women into computing degrees and the IT sector. In the UK, women are currently under-represented on computing courses. Meanwhile the IT industry requires more computing graduates, in general, and specifically more highly skilled women to create appropriate products and systems. The UK has recently introduced apprenticeship computing degrees, where the apprentice is a work-based employee. In some models, apprentices spend 20% of their time on Higher Education studies and also gain credits through work-based learning; in others, apprentices spend blocks of time in Higher Education and the workplace. These degrees offer a new and innovative route to studying computing at university. Largely funded by employers, apprentices are salaried, and their fees are paid, paving the way for more people to study for a degree. The work context enables apprentices to keep their jobs (if relevant) or to move into IT roles and start a computing degree without necessarily having computing qualifications; the degrees have no upper age limit. Extending the work-based approach of US cooperative education and student work placement models, apprenticeship degrees have been introduced to increase skills levels through a close partnership between universities and employers. This is particularly important in IT, where the sector is expanding, and employers are looking for both good technical and personal skills. With this model, employers are collaboratively involved in the design of the degrees and apprentices graduate with extensive work experience.

We posed the following research question: *Are there differences in the paths into computing apprenticeship degrees between women and men?* A survey was conducted with apprentices beginning a degree in Fall 2019: Cyber Security, Data Science, IT Management for Business, or Software Engineering/Development. Participants were asked about their routes into the apprenticeship and the IT sector. Apprentices at five universities in Scotland and one in Northern Ireland completed the survey, on paper or online (n=85; 23 female, 59 male).

The results revealed a less severe gender imbalance than with comparative on-campus degrees (28% female), but this varied greatly across the subjects, from Data Science, where 55% of respondents identified as female and IT Management for Business (40% female), to Software Development (27% female) and Cyber Security (only 11% female). Apprentices were more likely to have started the degree at least a few years after leaving school and this was especially true for women. More female respondents had also been with their current employer for over five years. However, women were slightly more likely to have joined their employers in order to start the apprenticeship.

This initial work identifies opportunities to recruit women onto computing degree apprenticeships, for example by targeting women who have started careers. It also highlights that there are challenges in recruiting women into certain subject areas, especially Cyber Security, but also Software Development. Exploring our respondents' motivations for choosing their subjects illuminates the gender balance challenge and indicates how degree apprenticeships can encourage more women into the IT sector.

Keywords— *women, gender, computer science, motivations, degree apprenticeship, graduate apprenticeship*

I. INTRODUCTION

A gender imbalance persists in the IT sector in the US, UK, and elsewhere. Even though under-representation of women is the focus of much purposeful and well-meaning activity [1], computer science remains a male-dominated university subject in the UK and consequently the IT sector is similarly male-dominated. There are many reasons why this is a challenge worth overcoming, beyond the overwhelming case for equality of opportunity. For example, the shortage of diverse skills stifles creativity and innovation [2], [3], impacting on economic growth. More compelling, at an individual level, is that technology needs to be designed and developed by representatives of eventual users, if it is to be appropriate for their diverse contexts [3]. A new educational approach might just make the long-awaited difference. So, this

study investigates this new route to a computing degree, appraising this potential opportunity to increase the participation of women, by carefully analyzing intake and considering how the degree is signposted and understood. In particular, equality of access may be promoted through illuminating the attitudes, perceptions, and agency of women entering the IT sector. These degree apprenticeships are innovative, in the UK, in terms of the extent of work-based learning, the involvement of employers in the content, and the finance model. These factors are central to current challenges and evolution in HE world-wide; so, it is essential to investigate their impact on women.

This study explored the goals and routes of new computing apprentices, embarking on apprenticeship degrees at universities in Scotland and Northern Ireland, focusing on gendered differences. The study brings considerations of gender in IT Higher Education (HE) up-to-date through a consideration of the unique position apprentices hold: navigating both degree study and IT workplaces simultaneously. As the women navigate between work and study, this research can also inform those designing and promoting cooperative and work integrated HE. This paper first reviews the literature on gender imbalance, then describes the study and presents findings, in order to consider whether the computing degree apprenticeship might present a good opportunity to redress the gender imbalance in the IT sector.

II. LITERATURE REVIEW

The literature review is presented under three themes: studies relating to women studying towards a computing degree; the literature on women and apprenticeships; and finally, insights into gender and the IT workplace.

A. Women Studying Computing

Only 18.3% of UK Computing Science (CS) students are women [4]. Such a lack of representation on CS majors is also reflected in Australia, continental Europe, and the US, and has been a persistent phenomenon for over 30 years [3]. The picture is also bleak for gender balance in the IT occupational sector, where only 16% of those working in IT occupations across the UK are women [5], 24% of IT roles in the US are filled by women [6] and only 3% of female students, in a UK study, said a tech job was their first choice of career [7].

Grounded in Oyserman's identity-based motivation model [8], the interests, expectations, and values of young women and men influence their constructions of possible future selves and how they approach potential difficulties, for example in their education and career. In studies trying to understand motivations to study CS, men are more likely than women to identify an interest in, or passion for, computing behind their reason to select a CS major [9], [10]. Female CS university students, in a study by Smith et al. [10] gave varied reasons for studying computing, including being influenced by family members and/or teachers. This was also reported by a study initiated by the IT sector [11]. Women also cited the opportunity of a well-paid job, as a reason to study CS [11], [10]; a pragmatic approach also found by Beyer [12]. Further motivational factors include self-perception of ability and prior experiences of learning [11]. Women also chose computing when they perceived its potential to have a positive impact on society [13]. Alignment of values and cultural expectations not only affect decisions to study computing [13], [14], but are also important for students to experience the "sense of belonging", which in turn predicts retention [15].

Achieving a sense of belonging may be more challenging for women in predominantly male environments [16]. Beyer [12] found that students who valued family life over careers were less likely to select a computing CS course; however, Armstrong et al. [17] revealed workplaces becoming more flexible and the possibilities for IT roles to be specifically family-friendly, for example through home-working.

Studies have shown that women can lack confidence in their abilities to study computing and other STEM subjects, presenting a potential barrier [18], [19]. This lack of confidence starts to take effect in early childhood through toys and game playing [20], [21]. Perceptions of technology mastery contribute to a self-efficacy gender gap [21] that affects decisions relating to selecting a computing subject at university [13]. Settle et al. [23] found that female CS students reported lower levels of self-efficacy; for example, they were less likely than male students to report that they were sure they could learn programming or successfully complete advanced work in computer science. Leslie et al. [24] argue that disciplines that portray success linked to innate talent or raw aptitude act to exclude women and minorities, due to internalized negative stereotyping.

Once enrolled, a positive experience of computing in the first year of university can act as a resource for self-identification as a skilled CS student [14]. Henwood [25] argues that simply achieving technical competence does not in itself lead to CS identity construction: female students in Henwood's study scored higher grades than male students, but still self-reported as failing or struggling. Instead, a new identity is inhibited by these female CS students' "continual exposure to symbolic constructions of gender-technology relations that offer women only marginal or outsider status within technological cultures" [p. 212].

Raelin et al.'s [26] study of the impact of cooperative education on women found that work self-efficacy increased through the experiences of multiple co-op placements. This finding gives some encouragement regarding gendered experiences of apprenticeships where the apprentice has work as a potential ongoing source of enhanced self-efficacy throughout the degree.

B. Women and Apprenticeships

Penn [27] argues that "ethnic and gender exclusion is central to apprenticeship structures historically in [...] Britain" [p. 259] which has created a white, male apprentice stereotype that is sufficiently entrenched that only affirmative action could challenge the "deep seated set of discriminatory employment practices". We find little evidence that the stereotype has evolved since Penn's study: in a study of young people's attitudes towards apprenticeships, Beck et al. found a "conservative approach by young people to labor market possibilities, and their willingness to conform to stereotypical notions of what men and women should do" [28, p. 682]. Miller [29] reiterates concerns that apprenticeships will "reinforce existing segregation in the workforce" [p. 284]. However, the opportunity of women taking up apprenticeships in the IT sector could accelerate progress as apprentices are both embedded in the workplace and part of an obvious network of apprentices spread across their various organizations, potentially fulfilling the first of Fuller and Unwin's criteria for supporting apprenticeships: "Participation in multiple communities of practice inside and outside the workplace" [30, p. 411]. Apprentices also, through the structures of their courses, enjoy the benefits of a

workplace mentor. Such in-work support has been found to contribute to ongoing learning and development in the IT sector [31]. However, Smith [32], while finding evidence of an improving situation of increased access to training for women in Australia, points out that women still face barriers to employment, including carrying the greater share of childcare. These barriers may also limit access to apprenticeships, with their dual demands of work and study. One of the aims of the pre-degree Modern Apprenticeship (MA) in Scotland was to challenge occupational segregation and ensure gender imbalance was no more than 75:25 on any MA. It was recognized that “the main cause of gender segregation is traditional, cultural norms and out-of-date value systems, including stereotypical views among key influencers (e.g. parents, teachers, peers) regarding young people’s choices in school subjects and jobs” [33, p. 11]. In spite of this aim, men have been more likely to apply for the higher-level MAs [34].

The Organisation for Economic Co-operation and Development (OECD) identifies the digital world as providing opportunities specifically for women’s economic empowerment, through additional employment opportunities, as well as facilitating daily life [35]. Inspired by this, digital degree apprenticeships have been specifically promoted to local women running small businesses [36]. The new UK computing degree apprenticeships have the potential to lead to higher paid, higher status work than many existing apprenticeships and for this reason wider awareness of cultural barriers to women applying is essential. Some of these cultural barriers are characterized by the ‘chilly’ workplace climate portrayed to women [37]. This takes us to the final section of the literature review which considers the IT workplace.

C. Women Observing and Experiencing the IT Occupational Sector

The shortage of women in the IT sector has been studied for many years with findings related to: concerns about the social usefulness of IT careers [38]; a lack of female role models, e.g., [39], [40]; unappealing stereotypes, e.g., [41], [42], [21]; unappealing workplaces with misogynist work colleagues [43]; and finally, low status jobs, combined with ongoing risks of outsourcing and offshoring [44]. With an occupation sector so apparently stacked against women, various outreach activities have been undertaken to try to counteract such preconceptions, e.g., [45], [39]. However, the gender imbalance in the UK, the US, and elsewhere remains problematic.

This is not just a problem with preconceptions, as the realities of women’s lives in IT lead to attrition rates from the sector twice those of men. This phenomenon has been described as a “leaky pipeline” [e.g., 41], and has been attributed to conflicts between work and family life, working culture, lack of mentoring, lack of networking opportunities [46], contracts with limited flexibility, expectations of long working days, and a lack of recognition [47]. With so few women in IT workplaces, combined with many leaving the sector, it is difficult to see how the current shortage of women (to act as role models, to contribute to networks, to provide support as mentors, to champion flexible contracts and to challenge misogynistic workplace cultures) might change in the near future.

Vitores and Gil-Juárez [48] argue against the leaky pipeline metaphor as it portrays women’s career choices as

failures—leaks—rather than rational choices in a sexist industry. This sexism is embedded in technology products, including designs, instructions, and advertising. For example, servile AI voice assistants, like Siri and Alexa, tend to display (and perpetuate) the gender biases of their male creators [49]. While this gendered technology might be off-putting to women, there is no escape from such technology at work. Aspirations towards a specific occupation are affected by visibility of the occupation, but also that which is “culturally thinkable” [50, p. 168]. Women are less positive about descriptions of masculinized working environments (e.g., featuring beer fridges, pool tables, and scooters) as somewhere they can belong [51]. When combined, these are likely to discourage female applicants. Rather than a problematic leaky pipeline, those escaping a career in the IT sector could be breaking free from a tunnel comprised of unfriendly male-dominated, linear constraints.

In this context, we start to investigate whether this new model for computing degrees—apprenticeship degrees, with the apprentice embedded in the workplace while studying for a computing degree—might be able to achieve a better gender balance than traditional on-campus courses, and retain women in the IT sector, while meeting their expectations of study and work. As the degrees are relatively new, in this study we look at the gender balance in several cohorts, the routes they took into the apprenticeship, and their previous experiences. Using survey data gathered from 85 degree apprentices, we explore their decision-making processes and influences, in order to consider how, in the future, CS HE and the IT sector might become more attractive destinations for women.

III. METHODOLOGY

Apprentices at five universities in Scotland and one in Northern Ireland were invited to complete a survey soon after they joined their undergraduate apprenticeship degrees in: Cyber Security, Data Science, IT Management for Business (ITMB), or Software Engineering/Development. Apprentices at one university completed the survey on paper; the others completed the survey online. A breakdown of participant demographics, for those who specified their gender as female or male, is shown in Table I. Three respondents chose “other” or “prefer not to say” for the gender question. Unfortunately, they need to be excluded from this analysis, as groups of less than five limit both the validity of comparison and respondents’ anonymity.

Participants (n=85) were informed about the privacy of the data they provided, including anonymity for storage, collaboration, and publication respectively, and asked for their consent. The survey asked about their routes into the apprenticeship and IT, including who/ what had influenced them, along with some demographic questions. The survey included both closed and open questions (Tables I to III and Tables IV to VII, respectively). As our previous research (surveys and interviews) had revealed a great diversity among the apprentices’ contexts, it was important to enable respondents to provide their own answers to certain questions [52]. The analysis addressed the research question: *Are there differences in the paths into computing apprenticeship degrees between women and men?* To code open text responses, categories were chosen to try to reflect the content of the responses, inductively and iteratively, evolving over three years of related surveys [53]. Responses were coded by two researchers (out of a pool of three) independently and any discrepancies were resolved by discussion [54]. Where

necessary, data from the respondent's other responses was used to clarify meaning. All material was co-coded, rather than just a sample, to maximize accuracy. For the comparative analysis in this paper, the themes were further coded as *dichotomies* [55]. Where a participant's response fell under a certain theme this was coded as 1, and 0 otherwise. For example, the response "to get a career out of it" was coded as 1 under the theme *improve career options* and 0 for the other options as listed in Table 4. However, it must be noted that zero does not indicate absence; only that it was not mentioned. Comparison of gender distributions were conducted using Chi-squared test of independence, only including the female (n=23) and male (n=59) responses. Where more than 80% of expected values were less than zero, the Fisher exact test was used instead. Significance level was set to $p < .10$ due to the small sample size of female participants. While this is acceptable, the researchers are aware that "increasing the significance level to a higher value allows for a larger chance of being wrong, but also makes it easier to conclude that the coefficient is different from zero" [56 p. 189].

IV. FINDINGS AND DISCUSSION

The results are structured into three sections. First, we present demographic information about our degree apprentices, followed by their background in terms of education and employment. We then explore gender differences in accessing the degree apprenticeship, and, finally, we consider gender differences in early interest in computing.

A. Demographics and Programme Choice

The majority of apprentices who participated in the survey were male, though proportions varied widely across the four programmes. Female representation was highest at 55% (n=6) for Data Science, 40% (n=4) for ITMB, 27% for Software Development (n=10) and 11% (n=3) for Cyber Security. Previously published Scotland-wide data for entrants to these courses in the previous academic year were: 18.2% female for Cyber Security; 27.1% female for ITMB; and 19.0% female for Software Development [57]. Data Science figures were not published but comparable data from one of the universities in the study were 50% female for Data Science. Overall, these figures are higher than the female proportion of first year computing undergraduate students from the universities who took part in this study, which range between 15% and 22% female. Cheryan et al. [58] found interesting differences between STEM subjects, with factors such as access to role models, persistent masculine cultures, and gaps in self-efficacy (caused by negative stereotypes of women) acting to deter women from applying for some STEM subjects compared with others. As a new subject area, Data Science has not yet established a strong culture (culture emerges from historically-based ideas and values [59]); so, focusing on female role models and incorporating female perspectives and values in the curriculum might help to maintain the early promise shown by better balance on the Data Science apprenticeship courses.

Representation from Black, Asian, and Minority Ethnic (BAME) group was low for both male (6 out 59; 10.2%) and female (1 out of 23; 4.3%) apprentices. The low percentage of female apprentices from BAME backgrounds suggests an intersectionality factor, compounding under-representation. This finding demands further investigation, as also requested by Rodriguez and Lehman [14].

TABLE I DEMOGRAPHIC INFORMATION

Characteristic		Female Count (%) (n=23)	Male Count (%) (n=59)	University data Average (Range) ^a .
Ethnic background	BAME	1 (4.3%)	6 (10.2%)	11.7% (4.3 - 30%)
	Mixed	0 (0.0%)	3 (5.1%)	2.1% (0 - 6.6%)
	White	22 (95.7%)	50 (84.7%)	82.3% (66.3 - 87.9%)
Age	21 or under	4 (17.4%)	20 (33.9%)	88.0% (77.2% - 93.7%)
	22 to 25	6 (26.1%)	9 (15.3%)	6.1% (3.8-9.9%)
	26 and over	13 (56.5%)	30 (50.8%)	5.9% (1.8-13.9%)

a. First year computing department data from participating universities

B. Previous Education and Employment

Apprentices were asked about their previous study experience in order to explore any gender differences in the route to entry (Table II). A greater proportion (26%; n=6) of the female apprentices had no previous further education (FE), HE or apprenticeship experience in comparison to the male cohort (18.7%; n=11). More male apprentices had completed a Modern Apprenticeship, or its equivalent (25.4% vs. female 17.4%). Several men (10.2%), but no women, seemed to be switching from other degree apprenticeships.

More women had previously completed a full university degree (34.8%; n=8) in comparison to the male cohorts (6.8% n=4.). While starting a second degree may not seem to be the most efficient or effective route to a formal CS qualification, this degree has salient advantages over, for example, studying a conversion master's course part-time. Apprentices do not pay fees for the apprenticeship degree and have a time allowance out of the workplace (e.g., 20%) to study, plus support from their employers in the form of a workplace mentor. Even so, this second undergraduate degree phenomenon might indicate either a lack of confidence to embark on a master's course, a lack of apprenticeships at master's level or a lack of awareness about master's level computing apprenticeships.

TABLE II PREVIOUS STUDY/ APPRENTICESHIP

Previous education and training		Female (n=23)		Male (n=59)		P value
		Count	% within gender	Count	% within gender	
No previous FE, HE or apprenticeship		6	26.0%	11	18.7%	
Previous apprenticeship	Started apprenticeship degree ^a	0	0.0%	6	10.2%	.095 (v=.239)
	Completed (e.g.) Modern Apprenticeship	4	17.4%	15	25.4%	
Previous further edu.	Started FE, but didn't complete	2	8.7%	4	6.8%	.937 (v=.040)
	Completed FE course(s)	9	39.1%	25	42.4%	
Previous higher edu.	Started HE, but didn't complete	5	21.7%	16	27.1%	.010 (v=.372)
	Completed degree	8	34.8%	4	6.8%	
	Completed postgrad. degree	0	0.0%	4	6.8%	

^a. E.g. switching course/ university.

Degree apprentices may be established in employment, looking to upskill with their employer's support, or recruited by the organization as an apprentice. To understand whether our participants were existing employees or recruited specifically, we asked about their routes in (Table III). The picture is complex. A higher percentage of women were new employees, hired directly to do this degree apprenticeship (39.1% vs. 28.8% male); the majority of respondents were with their employer when they started the degree (i.e. upskilling). Of these upskillers, the women were more likely to have been with their organizations for longer: more than half our female respondents (57%, n=8) had been with their organization for six years or more, compared to 31.7% (n=13) of male respondents). Interestingly, 20.3% (n=12) of the male apprentices had joined their employers on a previous (Modern) Apprenticeship, compared with only 4.3% of the women, which reflects Campbell and Gillespie's findings that Modern Apprenticeships enjoyed a greater take-up by men than women [35].

TABLE III. RECRUITMENT/ EMPLOYMENT HISTORY

Employment/ Recruitment		Female (n=23)		Male (n=58)	
		Count	% within gender	Count	% within gender
Were you taken on as an apprentice?	No	13	56.5%	29	49.2%
	Originally taken on in Modern Apprenticeship role	1	4.3%	12	20.3%
	Recruited to do this apprenticeship	9	39.1%	17	28.8%
	Not specified	0	0.0%	1	1.7%
Years with employer	Under 3 years	5	35.7%	18	43.9%
	3 to 5 years	1	7.1%	9	22.0%
	6 to 9 years	3	21.4%	6	14.6%
	Over 10 years	5	35.7%	7	17.1%

C. Choosing Degree Apprenticeships

Our participants were asked about their main aims in undertaking the apprenticeship degree (Table IV). The majority of the participants, both male and female, indicated that their main aims for doing the apprenticeship were: to gain knowledge and skill (61%); improve career options (41.5%); and gain a degree (35.4%). The combination of any of these three main aims with other factors make up 85% of these open responses.

TABLE IV AIMS OF APPRENTICESHIP AND RATIONALE

Aims in undertaking apprenticeship	Female (n=23)		Male (n=56)		P value	Cramer's V
	Count	% within gender	Count	% within gender		
Gain degree	8	34.8%	19	33.9%	.942	.008
Gain knowledge and skill	13	56.5%	35	62.5%	.621	.056
Improve career options / achieve career goals	8	34.8%	25	44.6%	.420	.091
Professional/ personal growth	6	26.1%	6	10.7%	.097	.195
To benefit employer	1	4.3%	4	7.1%	1.0	.052
To continue employment / work while learning	4	17.4%	12	21.4%	.768	.046

Chi-square test results are also shown in Table IV. None of the column proportions for male and female respondents were statistically significant, except for the item which relates

to personal growth and development at $p < 10\%$ (26.1% female vs. 10.7% male). This result supports previous work that has shown that women are motivated by personal goals including altruism [60].

TABLE V. REASONS FOR CHOOSING A DEGREE APPRENTICESHIP

Reasons for choosing the degree apprenticeship	Female (n=23)		Male (n=56)		P value	Cramer's V
	Count	% within gender	Count	% within gender		
Financial reasons	11	47.8%	15	27.3%	.071	.203
Can keep current job	7	30.4%	19	34.5%	.764	.034
Importance of/ integration with work experience	7	30.4%	18	32.7%	.882	.017
Increase employability/ career opportunities	1	4.3%	7	12.7%	.426	.123
Traditional degree did not suit	6	26.1%	13	23.6%	.786	.031
Opportunity	3	13.0%	1	1.8%	.072	.233

We asked our participants "Why did you choose this apprenticeship degree, rather than a traditional full-time degree?" and coded the free text responses, allowing multiple codes (Table V). For the female respondents, the most common reasons given for choosing the apprenticeship were: financial (47.8%); to keep their current job (30.4%); and the integration of learning with work experience (30.4%). Male respondents provided similar responses; however, for male apprentices, the main reason was to keep their current job (34.5%), potentially reflecting that a greater proportion of them were upskilling. There were some indicative differences in the proportion of male and female respondents including financial reasons and viewing the degrees as opportunities, with both themes appearing in a higher proportion of women's responses, which was significant at $p < .10$.

To try to understand how "culturally thinkable" [49] the apprenticeship was to male and female apprentices, we asked how they had heard about the apprenticeship degree, who they had received advice from (Table VI) and, finally, what the nature of the advice was. The majority of apprentices had heard of the apprenticeship through their work (60.2%); however, the spread of responses was wider for female respondents than for male (52% at work compared with 65%; 13% at school compared with 5%, 17% at an event compared with 9%). We infer that these apprenticeship opportunities need to be promoted *widely* to reach and benefit under-represented groups.

TABLE VI. HOW DID YOU HEAR ABOUT THE APPRENTICESHIP DEGREE?

How did you hear about the apprenticeship degree?	Female (n=23)		Male (n=57)	
	Count	% within gender	Count	% within gender
Apprenticeship.Scot/ SDS/ Gov. Website	1	4.3%	6	10.5%
Other online/social media	1	4.3%	3	5.3%
Work / Interview	12	52.2%	37	64.9%
School / college / training provider	3	13.0%	3	5.3%
University / event	4	17.4%	5	8.8%
Family / friend	2	8.7%	3	5.3%

A multiple choice (choose all that applied) question asked respondents who they sought/received advice from when considering the apprenticeship. The majority of the

apprentices received advice from their employers/line managers (64%). The proportion of female apprentices receiving advice from friends/partner was significantly higher (56.5% for female vs. 33.3% for male; $p=0.043$; Cramer's $V = .224$). This may reflect the level of cultural acceptance of the apprenticeship, or a propensity in women to ask their friends and partners for advice. The advice they received was also slightly different: women were more likely to have been advised that it was a good opportunity or given general positive encouragement (42% compared with 27% for men), whereas men reported more specifically being advised that the apprenticeship was good financially and/or due to work experience (19% compared with women 0%). It may be that the women and men were offered similar advice, but reflected on it differently [61].

D. Personal Interest in Computing

To ascertain where the interest in their course subject had come from, we asked what or who first inspired their interest in their field (Table VII). Most of the apprentices noted that their interest in computing stemmed from their own personal, long-standing interest (31.8% for female; 30.2% for male). Others were inspired through their experience of computing during their working life (27.3% female; 30.2% male). Women were more likely than men to have been inspired by a teacher/ at school (23% vs. 15%). This reflects previous findings relating to the importance of classroom experiences for women in helping to avoid the self-efficacy gap and encouraging a positive sense of belonging [e.g., 23].

TABLE VII. WHAT (OR WHO) FIRST INSPIRED YOUR INTEREST IN THIS FIELD?

What (or who) first inspired your interest in this field?	Female (n=22)		Male (n=53)	
	Count	% within gender	Count	% within gender
Personal interest/ longstanding interest / games	7	31.8%	16	30.2%
Family/ friend	3	13.6%	10	18.9%
Teacher / school / other course	5	22.7%	8	15.1%
Employer (current or previous) / job /career	6	27.3%	16	30.2%
Named role model / talk/ event	1	4.5%	3	5.7%

Finally, we asked when they first considered a career in their field (Table VIII). More than half of both male and female responses indicated that they started to consider a career in this area during their working life. This suggests that school career counselling is failing to promote the opportunities of a career in IT and perhaps more could be done to find work experience in the sector for school pupils, with consequent signposting of routes into an IT career. There were interesting differences between the two groups' responses, including that none of the female respondents had considered a career in computing in childhood, compared with 9.1% of male apprentices.

TABLE VIII WHEN DID YOU FIRST CONSIDER AN IT CAREER?

When did you first consider a career in this area?	Female (n=23)		Male (n=55)	
	Count	% within gender	Count	% within gender
Childhood	0	0.0%	5	9.1%
At school	5	21.7%	17	30.9%
After school or during FE or HE	4	17.4%	5	9.1%
During working life	14	60.9%	28	50.9%

This is aligned to studies finding that school students in Scotland who were encouraged to use computers at home were more likely to aspire to an IT career [41] and that boys are more likely to have access to computers in the home from a young age [21]. Career role models within families are important [40], as is enthusiasm and knowledge about opportunities in IT [41].

Schools and universities, working together and with the industry, could create opportunities to bring women working in digital—professionals and apprentices—together with school students, [41]. However, it is also important to publicize entry routes into skilled IT roles for people *throughout their careers*. In particular, if we agree that the IT sector needs women, it is important to understand their routes in and support these routes.

V. CONCLUSION

Overall, our findings indicate that computing degree apprenticeships *in themselves* are unlikely to significantly improve the gender balance amongst those studying CS and joining the IT sector. However, the small differences in the experience and motivations of our male and female respondents may inform universities offering apprenticeship degrees and employers employing apprentices. We have a unique opportunity to improve gender balance by i) promoting apprenticeship opportunities widely, including at school and in the workplace; ii) appealing to women directly by promoting the opportunity offered by the apprenticeship, emphasizing personal development; iii) by specific promotions to women returners or women looking for a career change. Encouraging participation in cooperative education and student work placements might serve, beyond the value of relevant work experience, to inspire young women to plan careers in the IT sector on graduation. However, it is also vital to support the clear path that emerged for women in our study: a migration to a career in IT from a non-IT role in an existing workplace. Meanwhile, the likely impact of our trailblazing cohort of women on these degrees as role models should not be under-estimated. They can become the role models, mentors, and network members that will support future female cohorts.

This study has some limitations. Due to the small sample size, it was not possible to group respondents further by age group or by course, which could potentially show some variations in the responses. Neither was it possible to include the very few respondents specifying non-binary or other genders. The use of dichotomies in analysis involving free text responses should also be interpreted with caution. Future research should include investigating why Data Science degrees attract a higher percentage of women, and future qualitative studies would be of value to understand how context and experience affect decisions in earlier settings (e.g., at school) and why women become attracted to IT careers during working life.

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REFERENCES

- [1] C. Frieze and J. L. Quesenberry, "From difference to diversity: including women in the changing face of computing," in *Proceeding of the 44th ACM Technical Symposium on Computer Science Education*, 2013.

- [2] N. Shadbolt, "Shadbolt Review of Computer Sciences Degree Accreditation and Graduate Employability". London: BIS, 2016. Available: <https://www.gov.uk/government/publications/computer-science-degree-accreditation-and-graduate-employability-shadbolt-review>
- [3] E. Trauth, "What can we learn from gender research? Seven lessons for business research methods," *The Electronic Journal of Business Research Methods*, vol. 9, no. 1, pp. 1-9, 2011.
- [4] HESA, "What do HE students study?" Higher Education Statistics Agency, Cheltenham, UK, 2018/2019. [Online]. Available: <https://www.hesa.ac.uk/data-and-analysis/students/what-study>
- [5] ONS, "Employment by Occupation", Office for National Statistics, London, UK, 2018. [Online]. Available: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/employmentbyoccupationemp04>
- [6] Accenture, "Cracking the gender code", 2016 [Online]. Available: https://www.accenture.com/t20170417T030444Z_w_us-en/acnmedia/Accenture/next-gen-3/girls-who-code/Accenture-Cracking-The-Gender-Code-Report.pdf
- [7] PWC, "Time to Close the Gender Gap", 2017 [Online]. Available: <https://www.pwc.co.uk/who-we-are/women-in-technology/time-to-close-the-gender-gap.html>
- [8] P. Kinnunen, M. Marttila-Kontio and E. Pesonen, "Getting to know computer science freshmen," *Proceedings of the 13th Koli Calling International Conference on Computing Education Research*, 2013.
- [9] D. Oyserman and L. James, "Possible Identities," in *Handbook of Identity Theory and Research*, S. Schwartz, K. Luyckx, and V. Vignoles V. (eds). New York, NY, USA: Springer, 2011, pp. 117-145.
- [10] S. Smith, E. Sobolewska, J. Bhardwaj, and K. Fabian, "Exploring women's motivations to study computer science," *IEEE Frontiers in Education Conference (FIE)*, October 2018, pp.1-7.
- [11] Google, "Women who choose computer science—what really matters: The critical role of encouragement and exposure," 2014. [Online]. Available: <https://static.googleusercontent.com/media/edu.google.com/en/pdfs/women-who-choose-what-really.pdf>
- [12] S. Beyer, "Why are women underrepresented in Computer Science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades," *Computer Science Education*, vol. 24, no. 2-3, pp. 153-192, 2014.
- [13] C. Lewis, R. Anderson and K. Yasuhara, "I Don't Code All Day: Fitting in Computer Science When the Stereotypes Don't Fit," in *Proceedings of the 2016 ACM Conference on International Computing Education Research*, 2016.
- [14] S.L. Rodriguez and K. Lehman, "Developing the next generation of diverse computer scientists: the need for enhanced, intersectional computing identity theory," *Computer Science Education*, pp. 1-19, 2018.
- [15] C. Lewis, P. Bruno, J. Raygoza, and J. Wang, "Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing," *Proceedings of the 2019 ACM Conference on International Computing Education Research*, pp. 11-19.
- [16] P. Sankar, J. Gilmartin, and M. Sobel, "An examination of belongingness and confidence among female computer science students," *ACM SIGCAS Computers and Society*, vol. 45, no.2, pp. 7-10, 2015.
- [17] D. Armstrong, C. Riemenschneider, and L. Giddens, "The advancement and persistence of women in the information technology profession: An extension of Ahuja's gendered theory of IT career stages," *Information Systems Journal*, vol. 8, no. 6, pp.1082-1124, 2018.
- [18] J. Hur, C. Andrzejewski and D. Marghitu, "Girls and computer science: experiences, perceptions, and career aspirations," *Computer Science Education*, vol. 27, no. 2, pp. 100-120, 2017.
- [19] B. Schinzel, "The contingent construction of the relationship between gender and computer science," *Proceedings International Symposium on Technology and Society—Women and Technology: Historical, Societal, and Professional Perspectives*, 1999.
- [20] J. J. Jirout and N. S. Newcombe, "Building blocks for developing spatial skills: Evidence from a large, representative US sample," *Psychological Science*, vol. 26, no. 3, pp. 302-310, 2015.
- [21] J. Margolis and A. Fisher, "Unlocking the clubhouse: Women in computing," Cambridge, MA, USA: MIT press, 2003.
- [22] A. Master, S. Cheryan, A. Moscatelli and A. N. Meltzoff, "Programming experience promotes higher STEM motivation among first-grade girls," *Journal of experimental child psychology*, vol. 160, pp. 92-106, 2017.
- [23] A. Settle, J. Lalor and T. Steinbach, "Reconsidering the Impact of CS1 on Novice Attitudes," *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, 2015.
- [24] S.J. Leslie, A. Cimpian, M. Meyer and E. Freeland, "Expectations of brilliance underlie gender distributions across academic disciplines," *Science*, vol. 347, no. 6219, pp. 262-265, 2015.
- [25] F. Henwood, "From the woman question in technology to the technology question in feminism: Rethinking gender equality in IT education," *European Journal of Women's Studies*, vol. 7, no. 2, pp. 209-227, 2000.
- [26] J. Raelin, M. Bailey, J. Hamann, L.K. Pendleton, R. Reisberg, and D. Whitman, "The Gendered Effect of Cooperative Education, Contextual Support, and Self-Efficacy on Undergraduate Retention," *Journal of Engineering Education*, vol. 103, no. 4, pp. 599-624, 2014.
- [27] R. Penn, "Social exclusion and modern apprenticeships: a comparison of Britain and the USA," *Journal of Vocational Education & Training*, vol. 50, no. 2, pp. 259-276, 1998.
- [28] V. Beck, A. Fuller and L. Unwin, "Safety in stereotypes?: The impact of gender and 'race' on young people's perceptions of their post-compulsory education and labour market opportunities," *British Education Research Journal*, vol. 32, no. 5, pp. 667-686, 2006.
- [29] L. Miller, "Addressing gender segregation in apprenticeships in England," *Education + Training*, vol. 47, no. 4/5, pp. 283-297, May 2005.
- [30] A. Fuller and L. Unwin, "Learning as Apprentices in the Contemporary UK Workplace: creating and managing expansive and restrictive participation," *Journal of Education and Work*, vol 16, no. 4, pp. 407-426, 2003.
- [31] K. Jubas, S. Butterwick, H. Zhu, and J. Liptrot, "Learning a living: practices and recognition of women's on-the-job and informal learning in the information technology field," *Journal of Vocational Education and Training*, vol. 58, no.4, pp. 483-496, 2006.
- [32] E. Smith, "A woman's work is never certificated? How the implementation of nationally recognised training in workplaces helps women get qualifications," *Journal of Vocational Education and Training*, vol. 58, no. 4, pp. 531-549. 2006.
- [33] SDS, "Equalities Action Plan for Modern Apprenticeships in Scotland," Skills Development Scotland, Glasgow, 2015. [Online] Available: https://www.skillsdevelopmentscotland.co.uk/media/40691/2869_sds_equalities_action_plan_digital_v7.pdf
- [34] J. Campbell and M. Gillespie, "Gender analysis of spending on the Scottish Modern Apprenticeship programme," *Local Economy*, vol. 32, no. 5, pp. 420-432. 2017
- [35] OECD, "The Digital Gender Divide: Include, Upskill, Innovate," Organisation for Economic Co-operation and Development, 2018, [Online] Available: <http://www.oecd.org/internet/bridging-the-digital-gender-divide.pdf>
- [36] S. McKnight, S. Collins, D. Way, and P. Iannotti, "Case study: establishing a social mobility pipeline to degree apprenticeships," *Higher Education, Skills and Work-based Learning*, vol. 9, no. 2, pp. 149-163. 2019, <https://doi.org/10.1108/HESWBL-01-2019-0012>
- [37] K.R. Reynoldson and D.A. Major, "How exclusive work climates create barriers for women in IS&T," In *Encyclopedia of Information Science and Technology, Fourth Edition*, M. Khosrow-Pour, Ed. Hershey, PA, USA: IGI Global, 2018, pp. 3382-3392.
- [38] A. Diekmann, E. Brown, A. Johnston, and E. Clark, "Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers," *Psychological Science*, vol. 21, no. 8, pp.1051-1057, 2010.
- [39] A. van Langen, "Girls and STEM choice in Dutch education: the strong gender segregation and the good practice of the Stimulation Policy," *Gender Studies & Research*, vol. 13, 2015.
- [40] L. J. Sax, K. J. Lehman, J. A. Jacobs, M. A. Kanny, G. Lim, L. Monje-Paulson and H. B. Zimmerman, "Anatomy of an enduring gender gap: The evolution of women's participation in computer science," *The Journal of Higher Education*, vol. 88, no. 2, pp. 258-293, 2017.
- [41] H. Graham, V. Fuertes, V. Egdell, and R. Raeside, "Women in ICT and Digital Technologies: An investigation of the barriers to women entering, staying, and progressing in the sector, and actions to

- ameliorate this,” 2016, [Online] Available: <https://www.napier.ac.uk/~media/worktribe/output-408031/women-in-ict-and-digital-technologies-executive-summary-251016.pdf>
- [42] V. A. Lagesen, “The strength of numbers: Strategies to include women into computer science,” *Social Studies of Science*, vol. 37, no. 1, pp. 67-92, 2007.
 - [43] K. Moore, M. Griffiths, H. Richardson, and A. Adam, “Gendered futures? Women, the ICT workplace and stories of the future,” *Gender, Work & Organization*, vol. 15, no. 5, pp. 523-542, 2008.
 - [44] R. Donnelly, D. Grimshaw and M. Miozzo, “Does the UK have a ‘comparative institutional advantage’ that is supportive of the IT services sector?” *New Technology, Work and Employment*, vol. 26, no. 2, pp. 98-112, 2011.
 - [45] C. Lang, J. Fisher, A. Craig and H. Forgasz, “Outreach programmes to attract girls into computing: how the best laid plans can sometimes fail,” *Computer Science Education*, vol. 25, no. 3, pp. 257-275, 2015.
 - [46] J. Main and C. Schimpf, “The Underrepresentation of Women in Computing Fields: A Synthesis of Literature Using a Life Course Perspective,” *IEEE Transactions on Education*, vol. 60, no. 4, pp. 296-304, 2017.
 - [47] T. J. Misa, “Gender codes: Why women are leaving computing”, New York, NY, USA: Wiley, 2011.
 - [48] A. Vitores, and A. Gil-Juárez, “The trouble with ‘women in computing’: a critical examination of the deployment of research on the gender gap in computer science,” *Journal of Gender Studies*, vol. 25, no. 6, pp. 666-680, 2016.
 - [49] M. West, R. Kraut, and H.E. Chew, “*I’d blush if I could: closing gender divides in digital skills through education*” EQUALS Skills Coalition, UNESCO, 2019 [Online] Available: <https://unesdoc.unesco.org/ark:/48223/pf0000367416>
 - [50] L. Chisholm, “Is this a way of understanding education-work relations? Cultural perspectives on youth transitions in Britain,” in *Education and work in Great Britain, Germany and Italy*, A. Jobert, C. Marry, L. Tanguy, H. Rainbird (Eds). London and New York: Routledge. 1997, pp. 160-176.
 - [51] A. Wynn and S. Correll, “Puncturing the pipeline: Do technology companies alienate women in recruiting sessions?” *Social studies of science*, vol.48, no. 1, pp.149-164, February 2018.
 - [52] D. Albudaiwi, “Survey: Open-Ended Questions,” in M. Allen, Ed., *The Sage encyclopedia of communication research methods (Vols. 1-4)*. Thousand Oaks, CA: SAGE Publications, Inc., pp. 1715-1716, 2017.
 - [53] Anonymous, “Bridging the Digital Skills Gap: Are computing degree apprenticeships the answer?” *Proceedings of the 24th Annual Conference on Innovation and Technology in Computer Science Education*, 2019.
 - [54] M. Lombard, J. Snyder-Duch, and C. Campanella Bracken, “Intercoder Reliability,” in M. Allen, Ed., *The Sage encyclopedia of communication research methods (Vols. 1-4)*. Thousand Oaks, CA: SAGE Publications, Inc., pp. 722-724, 2017.
 - [55] R.E. Boyatzis, *Transforming Qualitative Information—Thematic Analysis and Code Development*, Thousand Oaks, CA: SAGE Publications, Inc., 1998.
 - [56] J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, and R.L. Tatham, *Multivariate data analysis*, Upper Saddle River, NJ, USA: Prentice-Hall, 2013.
 - [57] SDS, “Graduate Apprenticeships Early Activity and Progress,” Skills Development Scotland, Glasgow, UK, 2019 [Online] Available: <http://www.skillsdevelopmentscotland.co.uk/media/45882/ga-report-2019.pdf>
 - [58] S. Cheryan, S.A. Ziegler, A.K. Montoya and L. Jiang, “Why are some STEM fields more gender balanced than others?” *Psychological Bulletin*, vol. 143, no.1, pp. 1-35, 2017.
 - [59] S.T. Fiske and H.R. Markus, Eds., *Facing social class: How societal rank influences interaction*, New York, NY, USA: Russell Sage Foundation, 2012.
 - [60] M-T. Wang and J.L. Degol. "Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions." *Educational psychology review*, vol 29, pp. 119-140, 2017.
 - [61] M. S. Archer, “Making our way through the world: Human reflexivity and social mobility,” Cambridge, U.K.: Cambridge Univ. Press, 2007.